OBSERVATION

Psoralen Plus Long-Wave UV-A (PUVA) and Bexarotene Therapy

An Effective and Synergistic Combined Adjunct to Therapy for Patients With Advanced Cutaneous T-Cell Lymphoma

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Background: Multimodality biological response-modifier therapy that includes photopheresis, interferon, and bexarotene is the standard of care in our institution for advanced cutaneous T-cell lymphoma with peripheral blood involvement. We added psoralen plus long-wave UV-A (PUVA) to this regimen in 5 patients with Sézary syndrome.

Observations: All patients responded with decreased Sézary counts, resolution of lymphadenopathy, and clearing of skin disease after the addition of PUVA. Adverse effects were well tolerated and managed via close clinical and laboratory follow-up.

Conclusions: The addition of PUVA to a multimodality immunomodulatory regimen in patients with Sézary syndrome can result in rapid and sustained remission of both skin and blood-borne disease. Further in vitro and in vivo studies are needed.

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WE HAVE described previously a patient with refractory stage IVA cutaneous T-cell lymphoma (CTCL), who demonstrated a dramatic and enduring response with the addition of bexarotene and psoralen plus long-wave UV-A (PUVA) to photopheresis and interferon gamma regimens.[1] We now present 4 additional cases with similar responses and discuss the possible biological mechanisms and therapeutic implications. A summary of the 5 cases can be found in the **Table**.

REPORT OF CASES

CASE 1 (ORIGINAL REPORT)

A 56-year-old white man with an 8-year history of stage IVA Sézary syndrome that was variably responsive to nitrogen mustard ointment, topical corticosteroids, oral retinoids (including acitretin, all-*trans* retinoic acid, and isotretinoin), interferon alfa-2a, interferon gamma, monthly extracorporeal photopheresis, and subcutaneous granulocyte-monocyte colony-stimulating factor, experienced rapid progression of his disease in 1999. He became more erythrodermic, developed increasing numbers of large, ulcerating nodules, and experienced worsening fevers and pruritus and enlarging lymphadenopathy. Large cells were noted on the peripheral smear, suggesting large cell transformation. In April 1999, computed tomography of the patient's chest, abdomen, and pelvis revealed enlarging axillary, mediastinal, retroperitoneal, and inguinal lymphadenopathy.

Twice-weekly PUVA was added to his current regimen of monthly extracorporeal photopheresis, granulocyte-monocyte colony-stimulating factor, interferon gamma, and isotretinoin. One month later, oral bexarotene was substituted for isotretinoin at a dosage of 150 mg/d. After the initiation of bexarotene (2 months) and PUVA (3 months) therapies, total clearing of cutaneous disease and resolution of fevers, pruritus, and lymphadenopathy was observed. The PUVA treatment was discontinued after 14 months owing to the development of 2 in situ melanomas. He has been maintained on photopheresis tapered to every 12 weeks, bexarotene (150 mg by mouth daily) and interferon gamma (1.6 million units subcutaneously 4 times per week). At 14 months after discontinuing PUVA therapy, his skin remained clear and his Sézary count was in the 5% to 7% range. At present, his bexarotene-induced hyperlipidemia has been controlled with 40 mg of atorvastatin and 200 mg of fenofibrate by mouth daily.

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Summary of Treatment and Outcomes of 5 Patients With Sézary Syndrome When PUVA Was Added to a Multimodality Regimen

Age, y/ Sex	Stage	Disease Duration From Diagnosis Until PUVA, mo	CD4/CD8 Ratio Before PUVA	Sézary Count Before PUVA, %	Therapies at Time of Addition of PUVA	Duration of PUVA Therapy	Adverse Events	Current CD4/CD8 Ratio	Current Sézary Count, %	Maintenance Regimen	Current Status
56/M	IVA	96	2.2	10-12	Monthly ECP; interferon gamma (1.6 million units 4 times weekly); bexarotene (150 mg/d)*	14 mo off PUVA for 19 mo	Development of 2 in situ melanomas	0.57	5-7	ECP (every 3 mo); interferon gamma (1.6 million units 4 times weekly); bexarotene (150 mg/d)	CR
65/F	IIIB	52	22.0	75-85	Monthly ECP; interferon gamma (1.6 million units 4 times weekly); bexarotene (225 mg/d)	16 mo	None	1.0	1-3	ECP (every 6 wk); interferon gamma (1.6 million units 4 times weekly); bexarotene (225 mg/d); monthly PUVA	CR
59/M	IIIB†	3	6.3	20-30	Monthly ECP; bexarotene (150 mg/d)	10 mo	None	3.2	5-8	ECP (every 6 mo); interferon alfa-2b (1.0 million units 3 times weekly); bexarotene (150 mg/d); PUVA (every 2 wk)	CR
73/M	IIIB	24	1.7	10-12	Monthly ECP; interferon alfa-α2b (2.4 million units 3 times weekly); bexarotene (150 mg)	5 mo off PUVA for 5 mo	Neutropenia with ANC <1000/μL without intervening opportunistic infections	22.0	6-10	Monthly ECP; interferon gamma (1.2 million units 3 times weekly)‡; bexarotene (75 mg/d)	PR while receiving PUVA; now with disease progression
64/F	IIIB	10	5.0	25-30	Monthly ECP; interferon alfa-α2b (2.4 million units 3 times weekly); bexarotene (150 mg/d)	4 treatments; off PUVA for 10 mo	PUVA burn	4.7	8-12	Monthly ECP; interferon gamma (1.6 million units 3 times weekly)‡; bexarotene (150 mg/d)	PR after 4 PUVA treatments; recurrent disease responding to PUVA

Abbreviations: ANC, absolute neutrophil count; CR, complete response; ECP, extracorporeal photopheresis; PR, partial response; PUVA, psoralen plus UV-A.
*Added 1 month after addition of PUVA.
†Folliculocentric type.
‡Changed from interferon alfa-2b owing to new onset of peripheral neuropathy which resolved within 2 months of the switch.

CASE 2

A 65-year-old African American woman presented with stage IIIB Sézary syndrome. Total body 0.01% nitrogen mustard ointment and UV-B therapies were started, resulting in marked improvement in her skin and decrease in size of her lymph nodes. Her white blood cell count remained elevated at 10.3×10^9/μL with 91% circulating $CD4^+CD7^-$ cells and a CD4/CD8 ratio of 48 by flow cytometry. She was started on monthly treatments of extracorporeal photopheresis, and interferon alfa-2a was administered subcutaneously 4 times per week. A year later, peripheral blood buffy coat analysis revealed 90% Sézary cells. Over the next 2 years, despite the addition of various retinoids (all-*trans* retinoic acid and later acitretin) and granulocyte-monocyte colony-stimulating factor injections administered after each photopheresis treatment, her disease continued to progress both clinically and in the blood, with an increase in the CD4/CD8 ratio from 47 to 95. Interferon alfa-2a was replaced by interferon gamma (1.6 million units subcutaneously 4 times weekly), and oral bexarotene (150 mg/d) was added. A second flow cytometry performed 7 months after the addition of interferon gamma and 3 months after the addition of bexarotene revealed an improved CD4/CD8 ratio of 27. However, the Sézary count remained high at 70% to 80%. Bexarotene dosage was increased to 225 mg/d. Ten months later, her Sézary count was essen-

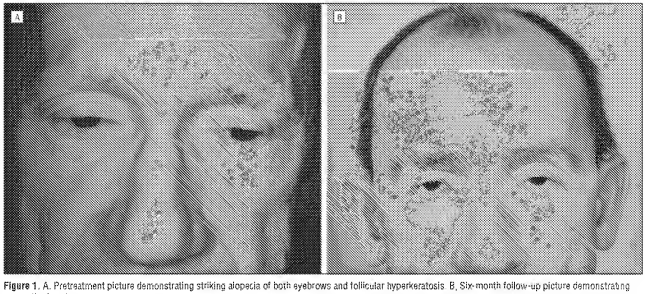

Figure 1. A, Pretreatment picture demonstrating striking alopecia of both eyebrows and follicular hyperkeratosis. B, Six-month follow-up picture demonstrating regrowth of eyebrows.

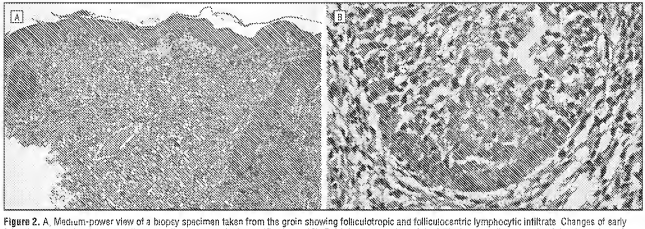

Figure 2. A, Medium-power view of a biopsy specimen taken from the groin showing folliculotropic and folliculocentric lymphocytic infiltrate. Changes of early follicular mucinosis are present (hematoxylin-eosin, original magnification ×10). B, Higher-power view of the follicular epithelium showing folliculotropism of enlarged and cerebriform lymphocytes (hematoxylin-eosin, original magnification ×40).

tially unchanged, and her $CD4^+/CD8^+$ ratio was 22. Three-times weekly PUVA was added, and within 1 month there was a dramatic decrease in her erythema and pruritus. At 2 months after the addition of PUVA, her Sézary count was 30% to 38% and her skin was clear. At 6 months after the addition of PUVA, the Sézary count was 5% to 10%, and the PUVA regimen was decreased to twice-weekly treatments. At 16 months after the addition of PUVA, her CD4/CD8 ratio was 1, her Sézary count was 1% to 3%, and her skin remained clear. Bexarotene-induced hypothyroidism and hyperlipidemia have been well controlled with the use of levothyroxine and fenofibrate, respectively.

CASE 3

A 53-year-old man presented with stage IIIB Sézary syndrome (folliculocentric-type with pruritus), extensive hair loss (**Figure 1**A), and nonpainful cervical, axillary, and inguinal adenopathy. Findings from a skin biopsy (**Figure 2**) were consistent with follicular mycosis fungoides, and a peripheral blood buffy coat analysis revealed 20% to 30% Sézary cells. Flow cytometry revealed an elevated CD4/CD8 ratio of 6, with an expanded population of $CD4^+CD7^-$ cells (45%). He was started on treatments with extracorporeal photopheresis, oral bexarotene (150 mg/d), and PUVA (3 times weekly). After starting PUVA (5 weeks) and bexarotene and photopheresis (8 weeks) therapies, the patient experienced hair regrowth in the affected areas as well as decreased lymphadenopathy. A second Sézary count was 7% to 10%. The PUVA regimen was decreased to 2 times per week. After starting PUVA (6 months) and bexarotene and photopheresis (7 months) therapies, there was continued hair regrowth (Figure 1B), and the Sézary count was 5% to 8%. Bexarotene-induced hypothyroidism and hypertriglyceridemia have been well controlled with levothyroxine and fenofibrate, respectively.

CASE 4

A 73-year-old white man presented with stage IIIB Sézary syndrome with a Sézary count in the 15% to 25% range. Over the following year, he experienced minimal re-

sponses to topical corticosteroids, 0.01% nitrogen mustard ointment to his entire cutaneous surface, interferon alfa-2b (2.4 million units subcutaneously 3 times weekly), and monthly extracorporeal photopheresis. Progression of his skin disease with worsening of his pruritus and scaling of the upper extremities, palms, and soles resulted in the addition of oral bexarotene to this regimen. Dosages were titrated up to 300 mg/d, at which point notable hypertriglyceridemia (865 mg/dL [reference range, 25-190 mg/dL]) developed, necessitating a decrease in dosage from 300 mg/d to 150 mg/d. Three-times weekly PUVA was initiated.

At 1 month after the initiation of PUVA, a Sézary count was 5% to 8%, and his skin was improved. At 2 months after initiation of PUVA therapy, an absolute neutrophil count of 608/μL was noted. His bexarotene dosage was decreased to 75 mg/d and interferon alfa-2b regimen to 2.4 million units 3 times weekly. One month later, there was continued improvement in his skin, but the neutropenia was persistent, with an absolute neutrophil count of 615/μL. This prompted decreases in PUVA regimen to twice weekly treatments and interferon alfa-2b regimen to 2.0 million units 3 times weekly, which was later substituted with interferon gamma owing to the development of peripheral neuropathy. The PUVA therapy was discontinued for personal reasons after 5 months of treatment. Since that time, there has been slow disease progression with worsening CD4/CD8 ratio, erythroderma, and pruritus. At present, his bexarotene-induced hypothyroidism has been controlled with levothyroxine, and bexarotene-induced hypertriglyceridemia has been controlled with atorvastatin and fenofibrate.

CASE 5

A 64-year-old white woman presented with stage IIIB Sézary syndrome. A Sézary count was 30% to 40%. Flow cytometry revealed a $CD4^+/CD7^-$ ratio of 5, with 19% cells displaying $CD4^+CD7^-$ markers. She was started on treatments with extracorporeal photopheresis and oral bexarotene (150 mg/d), with only mild improvement at 3 months. Therapy with interferon alfa-2b (1.8 million units subcutaneously 3 times weekly) was started, and 2 months later the regimen was increased to 2.4 million units, again with only mild improvement. A second Sézary count was 25% to 30%. Three-times weekly PUVA therapy was initiated. After only 4 PUVA treatments, she experienced 50% clearing of her skin disease. Another Sézary count, performed 1 month later, was 10% to 15%. Unfortunately, because of a burn during her fourth treatment, the patient refused to continue therapy. Recently, owing to the resurgence of skin disease, she has resumed PUVA treatment and is once again responding. Bexarotene-induced hypothyroidism and hypertriglyceridemia have been well controlled with levothyroxine and fenofibrate, respectively.

COMMENT

Multimodality biological response–modifier therapy is the standard of care in our institution for advanced CTCL. While no therapy thus far has been shown to be curative, combinations of therapies may work together to correct the immune abnormalities of this disease and to induce sustained remissions, and thereby improve both quality and quantity of life.[2] Recently, a new medication, bexarotene, has been added to our armamentarium of immunomodulators. A so-called "rexinoid," bexarotene is selective for the retinoid X receptors (RXR), unlike traditional retinoids (ie, isotretinoin and all-*trans* retinoic acid), which have a predilection for the retinoic acid receptors (RAR). Bexarotene's mechanism of action in CTCL is believed to be multifold and may work by inducing differentiation and enhancing apoptosis of the malignant T cells[3] while inhibiting inflammation and decreasing abnormal proliferation of the surrounding keratinocytes.[4]

In contrast with the recent introduction of bexarotene, the treatment of CTCL with PUVA was first reported in 1976 by Gilchrest et al[5] Its mechanism of action is believed to be via the binding of the UV-A–activated psoralen to DNA, resulting in apoptosis of neoplastic T cells in the skin and superficial capillaries. It may also effect lymphocyte function and migration.[5] The use of re-PUVA (the addition of oral retinoids to the PUVA regimen) in CTCL was first reported by the Scandinavian Mycosis Fungoides Group[7] in 1984. In 69 plaque-stage patients who were treated with PUVA or oral retinoids plus PUVA, the response rates were the same. However, the response was achieved with fewer PUVA treatments and lower cumulative UV-A dose in the setting of systemic retinoids. Moreover, the duration of remission was longer when maintenance retinoids were given. This apparent synergistic effect may be attributed to retinoid-induced reductions in epidermal thickness, enhancement of PUVA penetration, or retinoid-specific augmentation of immune functions.[8] We believe that retinoids may "prime" the malignant T cells, sensitizing them to UV-A–induced apoptosis (A.H.R., unpublished data, 2001).

Psoralen plus UV-A has also been used in combination with interferon alfa-2a in advanced stages of CTCL.[9] Among 15 patients treated with PUVA and interferon by Roenigk and colleagues,[9] at doses ranging from 6 to 30 million units 3 times weekly, 12 achieved complete responses, while 2 achieved partial responses, with a median duration of response of 23 months.

In our series, 3 (60%) of 5 patients had a complete remission with the addition of PUVA to a multimodality, immunomodulatory regimen. It is notable that of these 3 patients, 1 had large cell transformation and rapidly progressive lymphadenopathy, 1 had a highly elevated Sézary count, and 1 had a folliculotropic variant. Given the worse prognosis associated with these factors, we believed that the complete and sustained remissions that ensued were highly promising.[10] In the 2 patients with partial remission, PUVA was discontinued because of personal reasons (case 4) and PUVA burn (case 5). However, it is possible that additional treatment could have resulted in further improvement.

With respect to adverse events, 1 patient developed 2 in situ melanomas after 14 months of PUVA treatment. Although there was no family history or personal history of melanoma prior to his PUVA therapy, this pa-

tient did have a history of extensive sun exposure over his lifetime, with multiple sunburns as a child. Nevertheless, it is possible that other factors related either to the primary disease resulting in suppression of the skin immune surveillance system or to a specific interaction between PUVA and bexarotene resulting in increased melanocyte carcinogenesis occurred.

The addition of PUVA resulted in neutropenia (defined as an absolute neutrophil count of ≤1000/μL) in 1 patient, which necessitated a decrease in bexarotene, interferon, and PUVA dosage. Of note, no serious infections (viral, bacterial, or fungal) occurred during the period of neutropenia. Possible reasons for this neutropenia include decreased bone marrow production or increased peripheral destruction via a mechanism similar to that proposed for the destruction of the malignant T cells.

Finally, 1 patient experienced a PUVA burn, resulting in discontinuation of therapy despite a dramatic response. Though it is possible that bexarotene may potentiate PUVA resulting in burns at lower doses, this has not been our experience. Indeed, recent resumption of PUVA has not resulted in additional burns in this particular patient.

In summary, the addition of PUVA to a multimodality immunomodulatory regimen including extracorporeal photopheresis, bexarotene, and interferon in patients with Sézary syndrome can result in dramatic and sustained remission of both skin and blood-borne disease. While the mechanism for this effect requires further in vitro as well as in vivo investigation, we propose that bexarotene may act as a biological "primer," sensitizing the malignant T cells to PUVA-induced apoptosis. Finally, adverse effects of this combined regimen exist, but thus far they have been well tolerated and managed via close clinical and laboratory follow-up.

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